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WATER SUPPLY AND WATER QUALITY CONTROL STUDY, WAPSIPINICON RIVER BASIN, IOWA. STUDY OF THE NEEDS AND VALUE OF STORAGE FOR MUNICIPAL AND INDUSTRIAL WATER SUPPLY AND WATER QUALITY CONTROL

Federal Water Pollution Control Administration
Kansas City, Missouri

June 1966

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY WAPSIPINICON RIVER BASIN IOWA

Study of the Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control

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UNITED STATES
DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Kansas City, Missouri

June 1966

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General Publications

W19 Water Supply and Water Quality Control Study
Wapsipinicon River Basin - Iowa.

FWPCA Kansas City, Missouri June 1966

WATER SUPPLY AND WATER QUALITY CONTROL STUDY
WAPSIPINICON RIVER BASIN
IOWA

A study has been made of the Wapsipinicon River Basin which determined that there is no need for storage for municipal and industrial water supply nor for water quality control in the proposed Central City reservoir. These conclusions are based on economic, demographic and engineering studies.

Prepared for

DEPARTMENT OF THE ARMY
U. S. Army Engineer District
Rock Island, Illinois

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Federal Water Pollution Control Administration
Kansas City, Missouri
April 1966

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I. INTRODUCTION

Authority

The Corps of Engineers, U. S. Army Engineer District, Rock Island, Illinois, in letters dated October 29, 1964, and December 1, 1964, requested the Public Health Service,* Region VI, Kansas City, Missouri, to make a study of water supply and water quality control needs in the Wapsipinicon River Basin in connection with the proposed Central City Reservoir. This study has been made in accordance with a Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education and Welfare relative to Title III, Public Law 85-500 and the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq).

Purpose and Scope

The purpose of this study was to determine the present and future needs and value of municipal and industrial water supply and storage for water quality control on the Wapsipinicon River in the reaches affected by the proposed Central City Reservoir. This includes parts of the following Iowa counties: Clinton, Scott, Cedar, Jones, Linn, Delaware, Buchanan, Blackhawk, Bremer, Fayette, Chickasaw, Floyd, Howard, and Mitchell and small parts of Dodge and Olmsted counties in Minnesota.

The water requirements, and the means and benefits (both tangible and intangible) of meeting those requirements have been investigated.

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*Responsibility for water pollution control activities has been assigned to the Federal Water Pollution Control Administration by the Water Quality Control Act of 1965.

The scope of the study covers water storage needs during a one-hundred year study period, 1960 to 2060. The conclusions presented are tentative pending completion of a comprehensive water supply and water quality management study which will be conducted in this region by the Upper Mississippi River Basin Comprehensive Program for water supply and pollution control. The water quality flow requirements and values are suitable for project feasibility determinations.

Acknowledgments

The assistance and cooperation of State and Federal agencies and individuals are gratefully acknowledged by the Federal Water Pollution Control Administration. Particular appreciation is expressed to the following for data and advice furnished by their staff members:

U. S. Army Engineers, Rock Island District Corps of Engineers, Rock Island, Illinois

Iowa State Health Department, Division of Public Health Engineering, Des Moines, Iowa

Iowa Natural Resources Council, Des Moines, Iowa

Iowa State University, Civil Engineering Department, Ames, Iowa

Iowa State University, Department of Economics and Sociology, Ames, Iowa

State University of Iowa, Department of Civil Engineering, Iowa City, Iowa

United States Geological Survey, Water Resources Division, Iowa City, Iowa

United States Geological Survey, Ground Water Division, Iowa City, Iowa

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Corps of Engineers, Rock Island District, is investigating the feasibility of a reservoir on the Wapsipinicon River. The reservoir is located immediately above Central City, Iowa, or approximately 105 miles from the confluence of the Wapsipinicon River with the Mississippi River.

2. This study encompasses the entire Wapsipinicon River Basin with special emphasis on the reach below the proposed reservoir.

3. The total population of the principal municipalities in 1960 was 22,707.

4. Present water needs in the basin are supplied by ground water. The major water use is for municipal and industrial supplies with no heavy industrial water users.

5. All the major communities and most of the smaller communities that have sewage collection systems provide secondary treatment to their sewage. The exceptions are the communities of Olin and Oxford Junction, which have no treatment and Troy Mills, which has primary treatment. No areas of low dissolved oxygen concentration presently exist in the stream.

6. The water present in the streams and aquifers in the basin is generally of acceptable quality and is suitable for most municipal and industrial uses.

Conclusions

1. The total population of the principal municipalities is

projected to increase from 22,707 in 1960 to 29,000 in 2010 and 36,000 in 2060.

2. Based on population projection and anticipated per capita water use, it is estimated that the five major municipalities in the Wapsipinicon Basin will have an average daily water demand of 3.3 million gallons per day by 2010 and that it will increase to 5.3 million gallons per day by 2060.

3. Available ground water supplies are considered capable of sufficient yield to meet anticipated future demands. Because of the lesser degree of treatment needed, ground water supplies have been and are expected to continue to be preferred to surface supplies.

4. Available streamflows are considered sufficient to assimilate anticipated waste discharges, provided adequate waste treatment or other means of waste control are provided at the source; therefore, no storage for water quality control is recommended in the proposed Central City Reservoir.

III. PROJECT DESCRIPTION

The Central City Reservoir, as shown in Figure 1 in the appendix, is located in northeast Iowa approximately at the midpoint in the Wapsipinicon River Basin near the town of Central City. The drainage area contributing to the reservoir is approximately 1,273 square miles. The main purpose of the reservoir is to provide flood protection in the downstream reaches of the river and recreation. The discharge facilities as presently proposed will be a spillway on the left bluff. The spillway crest elevations, which are being considered, are from 870.0 feet mean sea level to 900.0 feet mean sea level. This corresponds to a surface area of 8800 acres to 24,400 acres and a capacity of 200,000 acre-feet to 650,000 acre-feet, respectively.

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

For this study the entire Wapsipinicon River Basin was considered with particular attention to the area immediate to the Central City Reservoir and the reach between the reservoir and the confluence with the Mississippi River. The Wapsipinicon River flows in a southeasterly direction, with its headwaters just inside Minnesota's southern border and from thence across the northeast corner of Iowa to the Mississippi River. The basin is long and uniquely narrow (225 miles by 10 miles), with a total watershed area of 2,540 square miles in which only ten are in Minnesota. The basin is one of the largest river systems which drain the northeast corner of Iowa.

Topography

In its upper basin, elevation 1,250 feet, the Wapsipinicon is a typical drift-prairie stream flowing through broad valleys not very much depressed below adjacent plains. Downstream the valley becomes deeper, except for notable exceptions. The valley maintains its drift-prairie nature with some areas being as much as two to three miles wide. The exceptions to this are at the reaches where resistant bedrock is crossed where the valley may narrow to less than one-half mile. The pertinent locations where these occur are: at Independence where the stream is confined by the rocky bluffs between 40 to 100 feet high; near Quasqueton in a location between gorges 100 to 130 feet deep; near Troy Mills where it follows a canyon 200 to 300 feet deep; at Anamosa where the valley is flanked by bold cliffs; and through restricted reaches, Oelwein and Hale

at Massilon, and near Big Rock. Below Big Rock the Wapsipinicon meanders sluggishly through valleys three to four miles wide. 5/

Climate

The normal annual precipitation for northeast Iowa is more than 33 inches, which includes an average snow fall of 38 inches. This varies from about 31 inches in the north part of the basin to 35 inches in the southern part. The historical records show the range to be approximately 40 inches to 14 inches. The seasonal distribution of precipitation is highly favorable to agriculture. 5/

The mean annual temperature for this area is 48° F. Temperatures in excess of 110° F and to less than below 40° F have been recorded.

Principal Cities and Industries

The principal cities in the study area are: Independence, Oelwein, Anamosa, Dewitt and Central City. The 1960 population of the largest of the cities, Oelwein, was 8,282, and the smallest, Central City, with 1,087.

No heavy water using industries are presently located in the basin.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

The streamflow in the Wapsipinicon River is characterized by high flow in the spring starting in March due to snow melt. The flow tapers off until approximately average flow is reached in May or June. Thereafter, the flow continues to decline until the lowest flows are reached in December or January. The streams in northeast Iowa in general have good low flow characteristics due to replenishment by ground water. This condition exists on the lower reaches of the Wapsipinicon River. The average annual runoff of the basin is 1341 cfs. The low flow characteristics are shown in Table V-1 and Table V-2 for the two gaging stations in the basin. The locations of the gaging stations are shown on Figure 1.

Table V-1

Magnitude and Frequency of Low Flows at Dewitt, Iowa in the Wapsipinicon River - cfs and cfs Per Square Mile[7/]

Low Flow Duration in Days	Recurrence Interval in Years					
	5		10		20	
	cfs	cfs Per Sq. Mi.	cfs	cfs Per Sq. Mi.	cfs	cfs Per Sq. Mi.
1	84	0.0360	63	0.0271	49	0.0210
7	100	0.0429	79	0.0339	65	0.0279
30	128	0.0550	100	0.0429	84	0.0361

Table V-2

Magnitude and Frequency of Low Flows at Independence, Iowa in the Wapsipinicon River - cfs and cfs Per Square Mile 7/

Low Flow Duration in Days	Recurrence Interval in Years					
	5		10		20	
	cfs	cfs Per Sq. Mi.	cfs	cfs Per Sq. Mi.	cfs	cfs Per Sq. Mi.
1	17	0.0162	12	0.0114	9.4	0.0090
7	23	0.0220	17	0.0162	14	0.0134
30	31	0.0296	22	0.0210	19	0.0181

For the purposes of analysis, the data at Independence were used for predicting flows into the reservoir and the data at Dewitt were used for predicting uncontrolled flow below the reservoir. As can be noted, the yield at the Dewitt station is considerably more than that at Independence. It is felt that this is due to heavy ground water replenishment in the lower reaches. Therefore, since it is estimated that this affect starts below Independence, it was used to predict the flows for the reaches below. The uncontrolled flow below the dam to the calculated critical section in the river is shown in Table V-3.

Table V-3

Magnitude and Frequency of Uncontrolled Flows to the Critical Reach in the Wapsipinicon River - cfs

Low Flow Duration in Days	Recurrence Interval in Years		
	5	10	20
1	5	4	3
7	7	5	4
30	9	6	6

The ground water supplies in the basin are quite plentiful and used by all municipalities as well as rural areas for their water supplies. All supplies from the consolidated rock aquifers are particularly reliable in this section of Iowa. The quality of the ground water is generally good. Appendix No. 1 shows the quality of the water from the different wells serving the municipalities in the basin. Most of the formations in the basin are important throughout most of Iowa. 5/

VI. THE ECONOMY

Economic and demographic studies of the Wapsipinicon River Basin are used in assessing future municipal and industrial and quality control water requirements.

The principal factors used in determining future water requirements are the population and industrial development. As these segments of the economy increase, the municipal and industrial water requirements and waste loads will also increase.

The narrow drainage basin of the Wapsipinicon traverses the following Iowa counties: Clinton, Scott, Cedar, Jones, Linn, Delaware, Buchanan, Blackhawk, Bremer, Fayette, Chickasaw, Floyd, Howard, Mitchell and in Minnesota Dodge and Olmsted. The limited geographic area of the basin (see Figure 1) restricts the use of countywide data. The area outside of the municipalities was analyzed; however, only population and heavy industrial waste loadings of the following municipalities were projected: Independence, Oelwein, Anamosa, Central City and Dewitt.

Past and Present

The economy of these municipalities is dependent primarily on the services supported by the agricultural activity in the surrounding area. 1/ With the exception of about four major manufacturing establishments which supply the national markets (Electrical Plant, Anamosa; Chemical Company in Oelwein; and Electrical Plant and Poultry Plant in Independence), the manufacturing establishments produce primarily for local consumption. 2/

Table VI-1

Population Data
Wapsipinicon River Basin Study
1910 - 2060

	1910	1920	1930	1940	1950	1960	2010	2060
Independence	3,517	3,672	3,691	4,342	4,865	5,498	7,000	8,600
Oelwein	6,028	7,455	7,794	7,801	7,858	8,282	10,600	13,300
Anamosa	2,983	2,881	3,579	4,069	3,910	4,616	6,000	7,400
Dewitt	1,634	1,849	2,041	2,205	2,644	3,224	4,000	5,000
Central City	558	688	780	810	965	1,087	1,400	1,700
	14,720	16,545	17,885	20,127	20,242	22,707	29,000	36,000

The total population of these municipalities has shown considerable growth in the past, increasing about 50 percent from 14,720 in 1910 to 22,707 in 1960, while the State as a whole increased about 25 percent from about 2.2 million to about 2.8 million during the same period. Population data for the study area and the State are shown in Table VI-2.

Future

An analysis of the projected population and economic conditions for the Wapsipinicon River Basin study has been restricted to a review of available studies conducted by Iowa State University and the Iowa Development Commission. 3/ 4/

The population of the study area is expected to continue its growth, the total increasing from 22.7 thousand in 1960 to approximately 29 thousand in 2010 and 36 thousand by 2060 (refer to Table VI-1). The past rates of population growth and the economic activities in these municipalities were similar; therefore, these five municipalities are expected to increase at the same rates. This rate of growth was derived from a survival rate procedure (C. Horace Hamilton and Joseph Perry, A Short Method for Projecting Population by Age from One Decennial Census to Another) conducted for the State. 3/

The present economic activity is expected to continue into the future. The manufacturing establishments are expected to continue to support the local market with a limited number of additional footloose industries, such as fabricated metal and electrical equipment. Additional industries which require substantial amounts of water for processing and contribute to pollution problems are not projected to locate in the study area. 4/

VII. WATER REQUIREMENTS - MUNICIPAL AND INDUSTRIAL

Present Water Uses and Sources

The municipalities in the basin with water supply systems are shown in Appendix No. 2. Ground water is used by all of the municipalities in the basin.

A minor use of surface and ground water is made for irrigation and several small projects have been constructed for recreation. However, the volumes involved are minor, being in the order of considerably less than one percent of the total annual runoff.

All municipalities in the basin obtain their water from wells. Appendix No. 2 shows the water supply facilities. The ground water in the basin is hard, but is considered of acceptable quality for normal use. Therefore, although the quantity of water available in the Wapsipinicon River is more than sufficient, the lesser amount of treatment needed for the ground water makes it a much more economical source. As stated in correspondence from the State Geologist, "In response to your inquiry, we have reviewed the available data and are of the opinion that there is sufficient ground water available in the Wapsipinicon River Basin in Iowa for the foreseeable future. I believe that it is safe to say that reserves will be adequate at least until 2020."

Future Municipal and Industrial Water Requirements

The results of the economic and demographic studies show a moderate increase in the population of the principal municipalities in the basin by 2060. Along with this growth, a moderate increase in the water used

per capita per day is anticipated.

The present average per capita water consumption for Iowa is 110 gallons per day.[2/] Since the Wapsipinicon River Basin has no heavy industries, it is felt that the present per capita use in the basin is somewhat less than this figure. In projecting future needs, a 115 gallons per capita per day in 2010 and 150 gallons per capita per day in 2060 were used.[2/] These figures include the small industries which are expected to locate in the municipalities. The results of the projected needs are shown in Table VII-1.

Table VII-1

Future Municipal and Industrial Requirements (MGD)

Wapsipinicon River Basin

Municipality	2010	2060
Independence	.8	1.3
Oelwein	1.2	2.0
Anamosa	.7	1.1
Central City	.2	.3
Dewitt	.5	.8

VIII. WATER QUALITY CONTROL

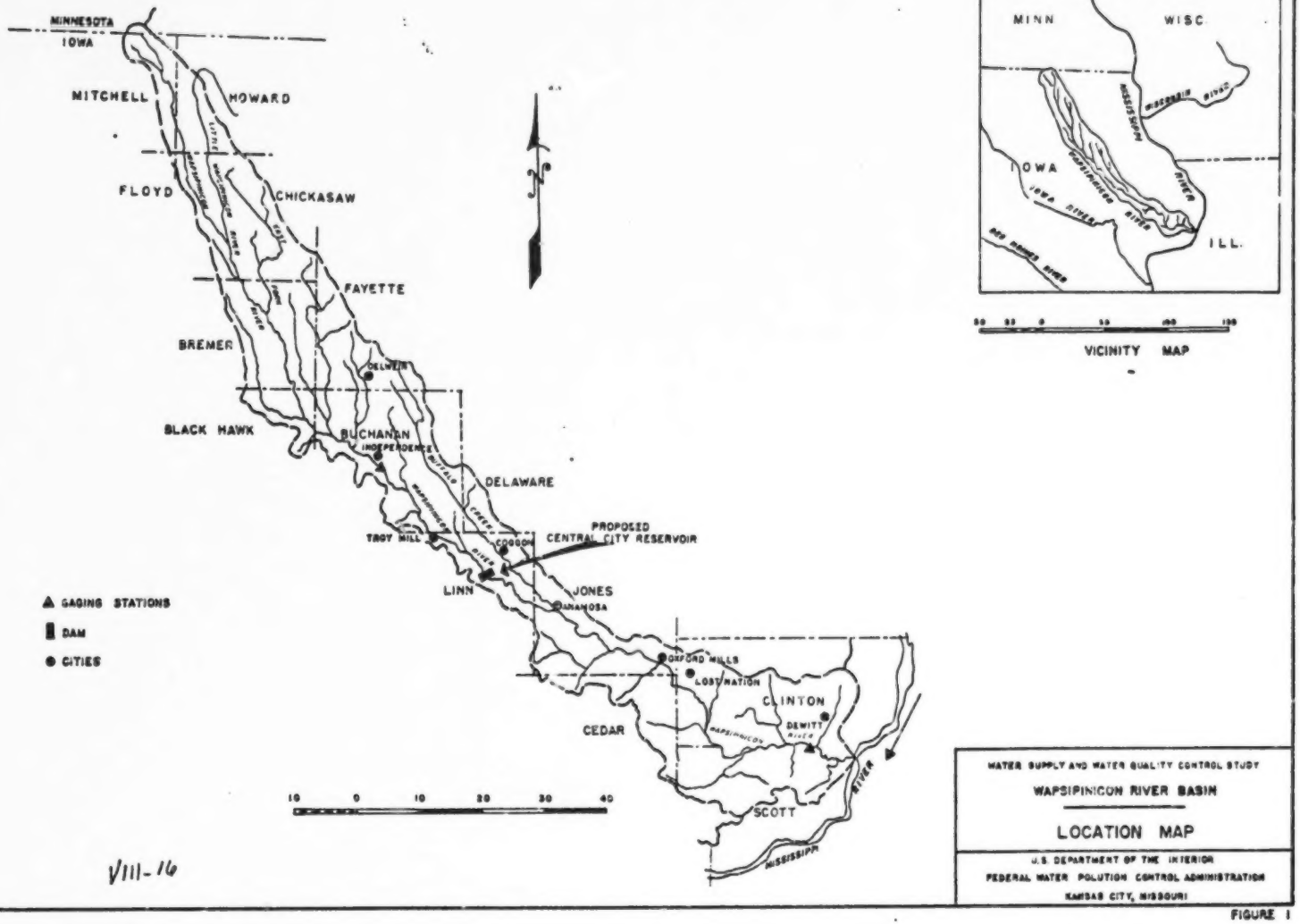
General

The use of water for municipal and industrial purposes will almost inevitably result in the production of some liquid waste which even after provision of adequate treatment could degrade the quality of the receiving stream. It is essential that recognition be given to the flows which are needed in the receiving stream if the quality of these waters is to be kept at acceptable levels. This need has been recognized in certain provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq), permitting the inclusion of storage for regulation of streamflow for quality control in Federal reservoirs. Consideration must be given to the inclusion of storage for regulation of streamflow for the purpose of water quality control. In the survey or planning of a reservoir by any Federal Agency, Section 3 of the Act expressly states that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at their source.

Municipal, Industrial, and Agricultural Pollution

The municipalities with public sewer systems which discharge their liquid waste into the stream are shown in Figure 2. Appendix No. 3 shows the pertinent data with respect to each municipality.

The reservoir can be used to augment flows in the downstream reaches. Therefore, the analysis of water quality needs was limited to this reach of the basin. Appendix No. 4 indicates the methodology used in determining



WATER SUPPLY AND WATER QUALITY CONTROL STUDY

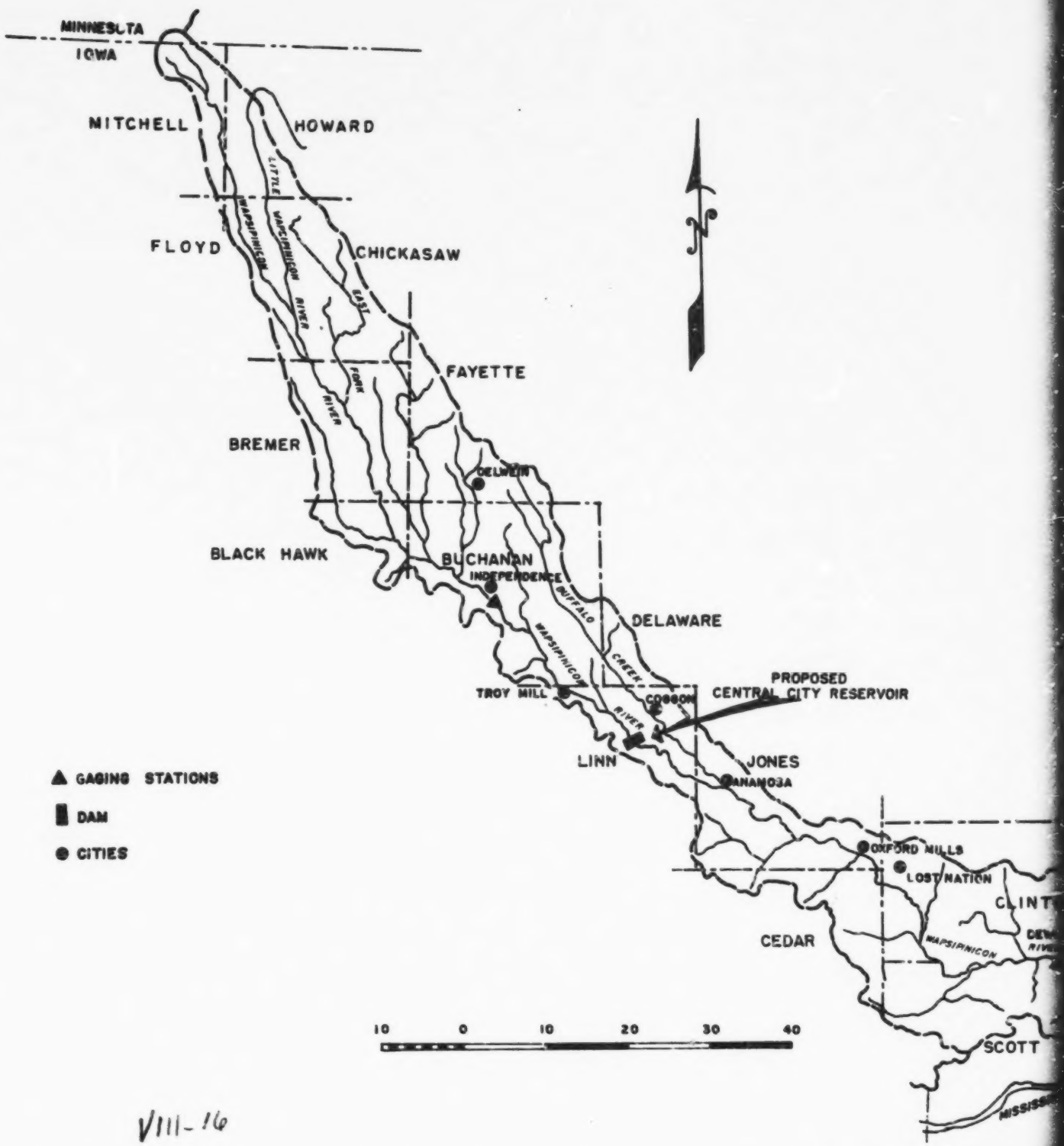
WAPSIPINICON RIVER BASIN

LOCATION MAP

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLUTION CONTROL ADMINISTRATION
KANSAS CITY, MISSOURI

FIGURE 1

A


MINNESOTA
IOWA
MITCHELL
HOWARD
FLOYD
CHICKASAW
FAYETTE
BREMER
BLACK HAWK
BUCHANAN
INDEPENDENCE
DELAWARE
PROPOSED
CENTRAL CITY RESERVOIR
TROY MILL
COGGON
LINN
JONES
ANAMOSA
OXFORD MILLS
LOST NATION
CEDAR
SCOTT
WAPSIPINICON
LITTLE WAPSIPINICON RIVER
EAST FORK WAPSIPINICON RIVER
BUFFALO CREEK
GAGING STATIONS
DAM
CITIES
10 0 10 20 30 40

VIII-16

B

VICINITY MAP

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

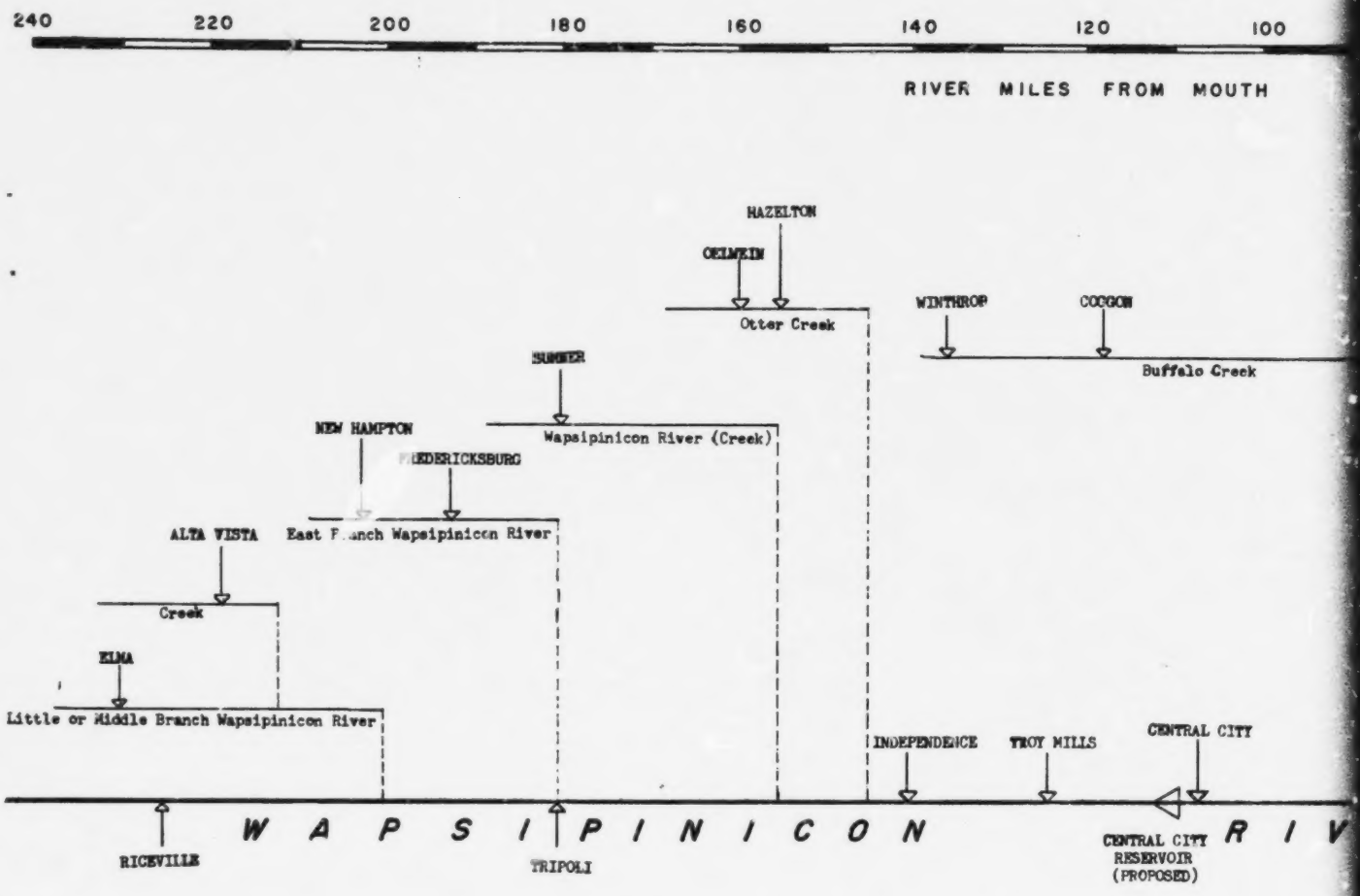
WAPSIPINICON RIVER BASIN

LOCATION MAP

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLUTION CONTROL ADMINISTRATION
KANSAS CITY, MISSOURI

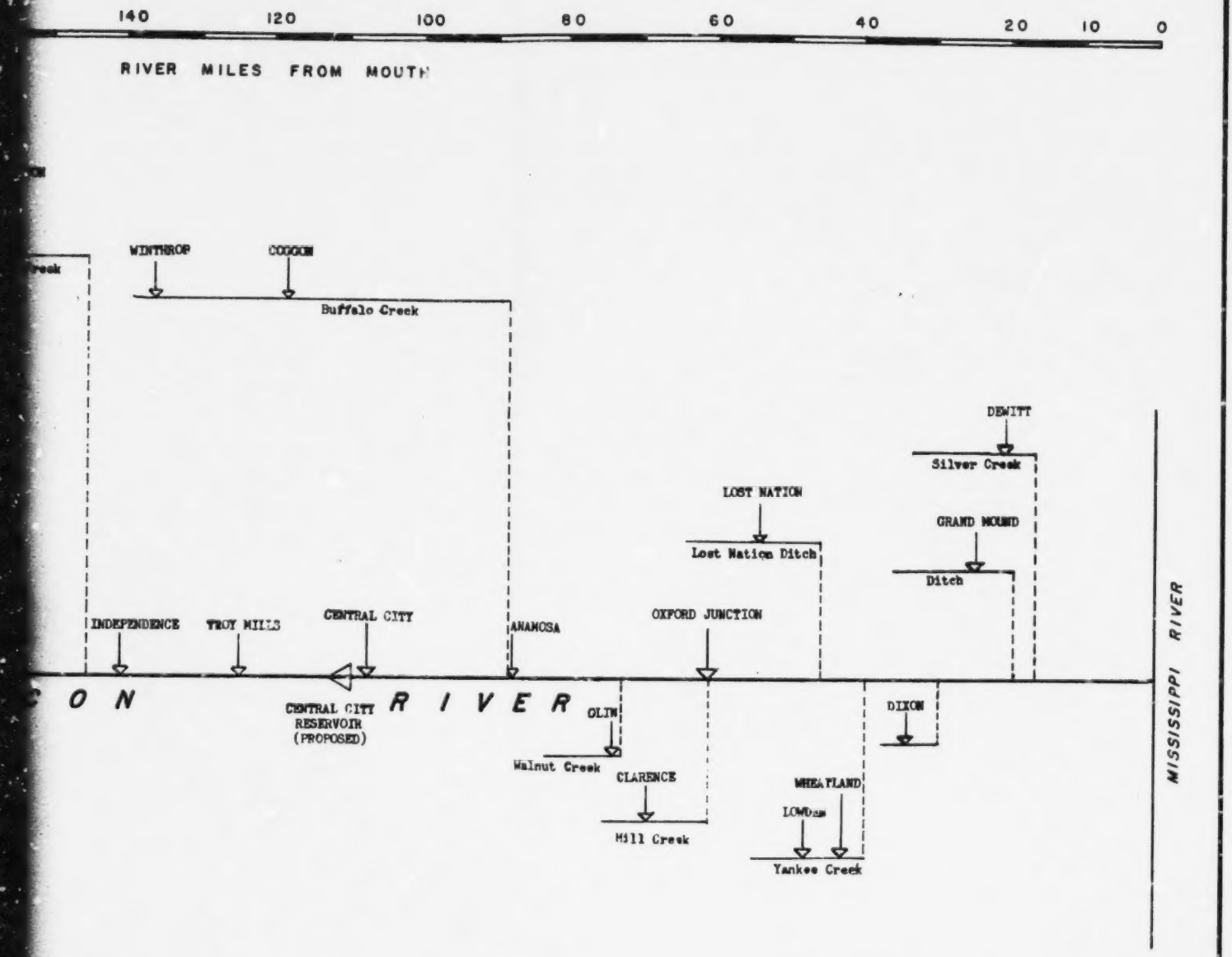
FIGURE 1

A



USAB CITY-66-1274H

B



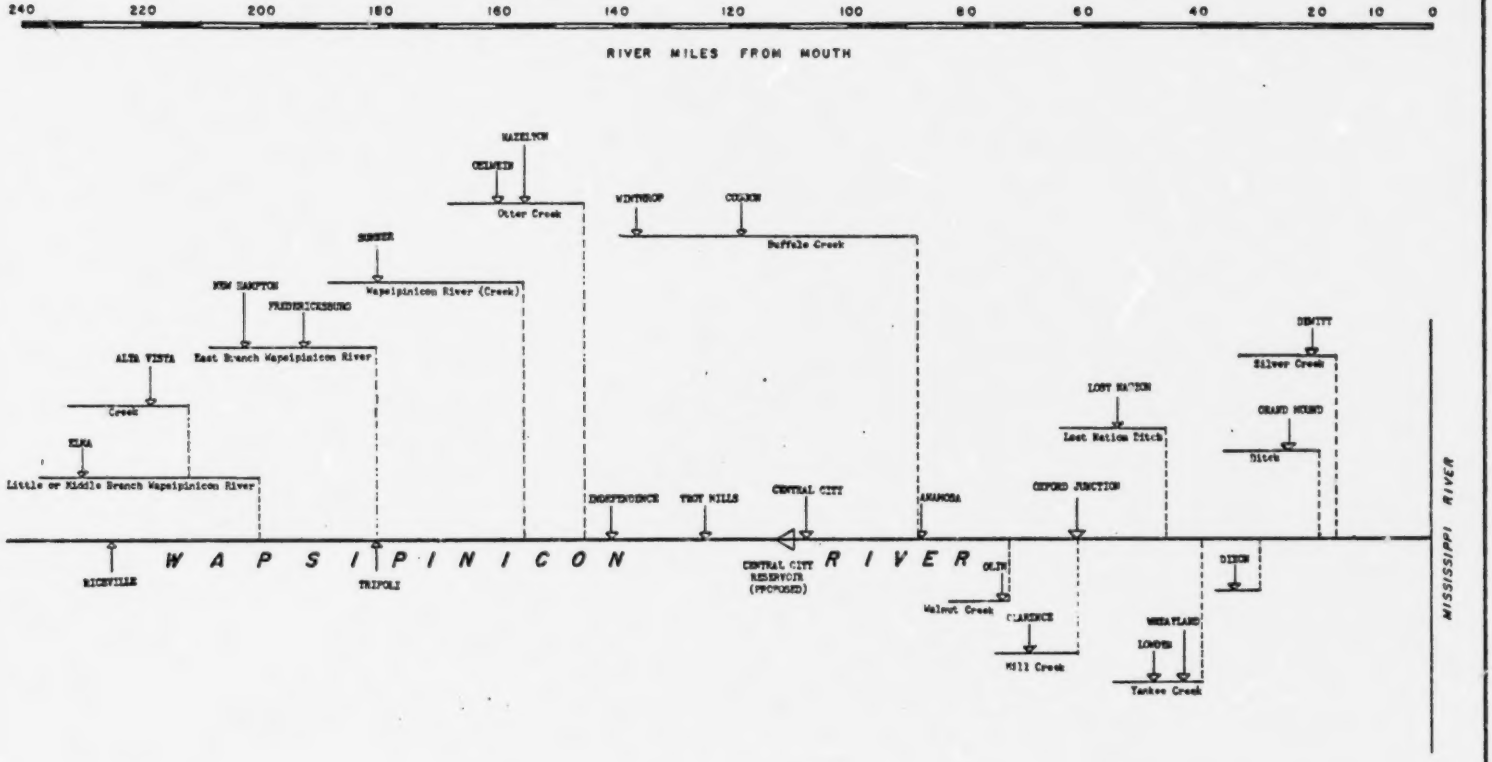
WATER SUPPLY AND WATER QUALITY CONTROL STUDY

WAPSIPINICON RIVER BASIN

SCHEMATIC DRAWING

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
FEDERAL WATER POLUTION CONTROL ADMINISTRATION
REGION VI KANSAS CITY, MISSOURI

FIGURE 2



WATER SUPPLY AND WATER QUALITY CONTROL STUDY

WAPSIPINICON RIVER BASIN

SCHEMATIC DRAWING

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
FEDERAL WATER POLUTION CONTROL ADMINISTRATION
REGION VI KANSAS CITY, MISSOURI

FIGURE 2

VIII-2

GSA-KANSAS CITY 66-1274H

the effect of the organic pollution. No data is available on the concentration of inorganic pollution. No problem from this type of pollution has been reported in the streams in this area of Iowa. In the economic projections of this basin no increase in industrial or agricultural pollution from inorganic wastes is foreseen. The present large populations in the stream of game fish give an indication that the quality of the water is at a reasonable level. Since no increase of inorganic pollution is foreseen, no problems from this type of pollution is expected.

Water Quality Criteria

The major uses of surface waters in the Wapsipinicon River Basin are for recreation and waste disposal. Some livestock watering and irrigation use is practiced.

The recreational uses include fish and wildlife propogation. The full reach of the river from the mouth to the headwaters is presently fished. Species in order of importance in these waters are: channel catfish, crappie, bluegill, small mouth bass, walleye and northern pike.

The Eastern Iowa River Basins have many advantages for the development of recreational facilities. The topography and absence of heavy population make this area ideal for recreational uses. Much camping, picnicking, hiking, fishing, boating, swimming, and hunting are practiced in the basin. All these activities depend either directly or indirectly on having streams of good quality water. Due to these uses, it is recommended that the minimum dissolved oxygen content be maintained at a level of 5 mg/l or above. This criterion has been endorsed by the Iowa State Health Department and the State Conservation Commission, the two agencies involved with water pollution control in the State of Iowa.

The attainment of this goal will allow the Wapsipinicon River to be used for all other uses as well as recreation.

Maintenance of this goal will require provision of adequate treatment for all municipal and industrial wastes.

Flow Regulation

Analysis of the effects of anticipated waste loads in the Wapsipinicon River indicates that the point of maximum loading will be at the reach immediately below Anamosa. This will occur as a result of the loading from Central City, Coggon, and Anamosa, along with minor loads from natural pollution and a few small towns. Based upon the mathematical model used, provision of adequate treatment, and the seven-day duration once-in-ten year drought flow, no oxygen sag will occur in the river either under present or future conditions. Thus, the dissolved oxygen content will remain at 5 mg/l and above. It should be noted that the proposed design of the outlet does not allow for a controlled release. No recommendation is made concerning a minimum release as the dam will act as a run-of-the-river structure and under the criteria of using the seven-day duration once-in-ten year flow no degradation due to low dissolved oxygen will occur.

The effect of any pollution on the Mississippi River resulting from the Wapsipinicon River is negligible. The biological oxygen demand in the Wapsipinicon River at the point of confluence will be low (less than 4 ppm) and the water will be approximately saturated with dissolved oxygen. The average flow of the Mississippi River at this point is approximately 47,100 cfs, as compared to 1341 cfs from the Wapsipinicon River. Since

the contribution to the flow in the Mississippi River is insignificant, being in the order of 2 percent of the flow, the impact on the dissolved oxygen content would be unnoticeable.

BIBLIOGRAPHY

1. Bureau of the Censes, U. S. Census of Population: 1950-1960, Volume II, "Characteristics of the Population" U. S. Government Printing Office, Washington, D. C., 1952-1961.

2. Iowa Development Commission, Directory of Manufacturers, Iowa, 1961, "A Buyers Guide for Iowa Products," 1961.

3. Wilbur R. Maki, Projections of Iowa's Economy and People in 1974, Department of Economics and Sociology, Special Report No. 41, Iowa State University of Science and Technology, 1965.

4. Richard E. Suttor and Wilbur R. Maki, Investment Opportunities in Meat Packing in Iowa, Iowa Development Commission.

5. Iowa Natural Resources Council, An Inventory of Water Resources and Water Problems, Northeastern Iowa River Basin, 1958, State House, Des Moines, Iowa.

6. P.H.S., A Comprehensive Program for Water Pollution Control for the Mississippi-Wapsipinicon and Tributaries River Basin, 1953, U. S. Department of Health, Education and Welfare, P. H. S., Publication No. 347.

7. Schwob, Harlan H., Low-Flow Characteristics of Iowa Streams, 1959, Iowa Natural Resources Council, U. S. Geological Survey, Water Resources Division, Bulletin No. 9.

8. Select Committee on National Water Resources, U. S. Senate, Water Resources Activities in the United States, Committee Print No. 7.

APPENDIX

A

Municipality	Date Installed	Well Depth	Chief Aquifer	Point of Collection	Date Coll
Anamosa	1894	350	Silurian Dolomite	Well #1	8-
	1955	403	Silurian Dolomite	Well #2	8-
		375		Well #3	12-
Calamus	1937	278	Silurian Dolomite	Well #1	12-
Central City	1912	106	Silurian Dolomite	Well #1-South	7-
	1912	104	Silurian Dolomite	Well #2-North	7-
Clarence	1919	160	Silurian Dolomite	Well #2	10-
	1950	200	Silurian Dolomite	Well #3	10-
				Plant Effluent	10-
Coggon	1894	270	Silurian Dolomite	Well #1	10-
	1910	270	Silurian Dolomite	Well #2	10-
DeWitt	1923	1646	Sil.Dol-Ga.-Platt.-St.P.-Dres. Ss	Well #3	7-
	1948	1421	Ga.through St.L. formations	Well #5	7-
Dunkerton	1941	255	Silurian Dolomite	Well #1	7-
Elma	1914	134	Pleistocene Sand & Gravel	Well #1	6-
Fairbank		219	Silurian Dolomite	Well #1	5-
	1957	206	Silurian Dolomite	Well #2	5-
Fredericksburg	1956	790	St. Peter Sandstone (?)	Well #1	11-
				Plant Effluent	5-
Grand Mound	1937	253	Silurian Dolomite	Well #1	8-
Hazleton	1953	65	Pleistocene Sand & Gravel	Well #1	8-
Ionia	1950	250	Cedar Valley & Sil. Ls & Dol.	Well #1	8-

B

Appendix No. 1

Quality of Well Water

	Point of Collection	Date of Collection	pH	Dissolved Solids	Total Solids	Soluble Iron	Total Iron	SiO_2	Alkalinity P	Alkalinity T	
ite	Well #1	8-1-60	7.5	276	276	0.06	0.06	13.2	0	294	2
ite	Well #2	8-1-60	7.4	424	424	0.06	0.06	14.8	0	328	3
	Well #3	12-9-63	7.1	485	485	0.16	0.16	20.4	0	290	1
ite	Well #1	12-12-62	7.6	220	220	1.1	1.1	17.2	0	226	1
ite	Well #1-South	7-13-59	7.5	358	358	0.04	0.04	14.8	0	266	3
ite	Well #2-North	7-13-59	7.5	322	322	< 0.02	< 0.02	14.8	0	264	2
ite	Well #2	10-30-61	7.5	281	281	1.5	1.5	16.8	0	268	0
ite	Well #3	10-30-61	7.3	359	359	1.1	1.1	16.6	0	288	0
	Plant Effluent	10-30-61	7.5	332	332	0.24	0.24	16.6	0	284	0
ite	Well #1	10-23-61	7.4	319	319	0.06	0.06	12.8	0	242	1
ite	Well #2	10-23-61	7.4	319	319	0.04	0.04	12.8	0	244	1
tt.-	Well #3	7-22-60	7.6	496	496	0.72	0.72	9.4	0	264	13
L.	Well #5	7-22-60	8.8	585	585	0.14	0.14	8.4	30.0	304	14
ite	Well #1	7-11-59	7.5	280	280	0.80	0.80	11.4	0	260	2
d	Well #1	6-28-59	7.4	464	464	< 0.02	< 0.02	15.8	0	252	1
ite	Well #1	5-26-59	7.4	361	361	2.44	2.44	8.8	0	270	2
ite	Well #2	5-26-59	7.4	323	323	3.84	3.84	13.2	0	260	1
	Well #1	11-7-62	7.6	279	279	0.40	0.40	8.4	0	214	6
	Plant Effluent	5-18-59	7.8	302	302	0.22	0.22	6.6	0	246	6
ite	Well #1	8-1-59	7.5	296	296	1.76	1.76	18.2	0	258	0
d	Well #1	8-3-59	7.6	292	292	0.08	0.08	13.8	0	200	0
Sil.	Well #1	8-14-59	7.4	356	356	0.64	0.64	11.8	0	270	2

C

K	Na	Ca	Mg	Mn	NO_3	F	Cl	SO_4	HCO_3	CO_3	Hardness as $CaCO_3$
.1	12.3	80.8	32.6	< 0.05	4.0	0.2	14	40.7	359	0	336
.2	17.9	94.0	38.2	< 0.05	14.6	0.2	14	64.2	400	0	392
.9	11.9	107	30.1	0.15	10	0.15	17	87.1	354	0	392
.1	6.1	57.6	19.7	< 0.05	< 0.4	< 0.1	0.5	22.2	276	0	225
.9	7.2	84.0	20.9	< 0.05	17.7	0.1	11	25.7	325	0	296
.9	6.0	78.8	23.1	< 0.05	14.6	0.1	7	20.8	322	0	292
.6	6.2	70.4	21.4	0.06	< 0.4	0.25	1.5	7.4	327	0	264
.9	6.0	84.8	25.3	0.06	< 0.4	0.25	1	40.9	351	0	316
.8	6.6	83.2	26.2	0.06	< 0.4	0.25	1.5	42.2	346	0	316
.1	7.8	72.0	25.3	< 0.05	1.8	0.15	10	36.8	295	0	284
.1	7.8	73.6	24.8	< 0.05	1.8	0.15	10.5	43.0	298	0	286
.9	100	47.0	21.0	< 0.05	0.9	1.0	69	74.5	322	0	204
.9	126	52.1	24.7	< 0.05	1.3	1.15	89	82.5	298	36.0	232
.1	15.4	68.8	15.6	< 0.05	< 0.4	0.75	2	9.9	317	0	236
.0	15.7	94.1	27.4	< 0.05	27.9	0.1	21	76.5	307	0	348
.0	5.5	80.8	19.9	< 0.05	0.4	0.7	3	31.7	329	0	284
.3	10.7	84.0	23.8	< 0.05	1.3	0.6	8	49.8	317	0	308
.0	11.4	53.6	23.1	< 0.05	1.3	0.6	1	29.4	261	0	229
.9	21.2	53.6	24.8	< 0.05	2.7	1.4	< 0.5	44.2	300	0	236
.9	6.3	67.2	25.3	< 0.05	< 0.4	0.15	4	14.4	315	0	272
.9	3.2	74.0	15.3	< 0.05	11.3	0.1	4	20.4	244	0	248
.5	13.7	78.8	27.0	< 0.05	9.3	0.8	< 0.5	40.3	329	0	308

A

Municipality	Date Installed	Well Depth	Chief Aquifer	Point of Collection	Date of Collecti
Independence	1923	205		Well #1	11-27-6
	1923	150	Devonian & Silurian Dol.	Well #2	10-12-6
	1943	307	Devonian & Silurian Dol.	Well #3	10-12-6
	1948	312	Devonian & Silurian Dol.	Well #4	10-12-6
Lowden	1933	1385	St. Peter Ss-P.C. Dol. Jor. Ss	Well #1	10-20-5
Lost Nation	1912	118	Silurian Dolomite	Well #1	10-20-5
New Hampton	1935	306	C.V.Ls&Dol-Ma. Ls&Dol.	Well #3	1-17-61
	1948	306	C.V.Ls&Dol-Ma. Ls&Dol.	Well #4	1-17-61
Oelwein	1931	121	Silurian Dolomite	Well #31	5-20-57
	1934	120	Silurian Dolomite	Well #34	5-20-57
	1942	1265	Ga.-St.P.-P.C.-Jor.	Well #42	5-20-57
	1958	1417	Ga.-P.C. St.L.	Well #58	3-14-60
Olin	1910	180	Silurian Dolomite	Well #1	1 17-62
Oxford Junction	1910	30	Recent Sand & Gravel	Well #1	1-8-62
Pleasant Hill			Purchases from Des Moines, Iowa		
Prairieburg	1911	180	Silurian Dolomite	Well #1	3-8-60
Readlyn	1958	170	Silurian Dolomite	Well #1	3-28-63
	1960	154		Well #2	3-28-63
				Plant Effluent	3-28-63
Riceville	1917	500?	Cedar Valley (?)	Well #1	3-29-62

B

Appendix No. 1

Quality of Well Water

fer	Point of Collection	Date of Collection	pH	Dissolved Solids	Total Solids	Soluble Iron	Total Iron	SiO_2	Alkalinity P	Alkalinity T	
	Well #1	11-27-62	7.4	345	345	0.10	0.10	11.6	0	232	
Silurian Dol.	Well #2	10-12-60	7.5	222	222	0.83	0.83	12.4	0	224	
Silurian Dol.	Well #3	10-12-60	7.6	218	218	0.08	0.08	10.0	0	230	
Silurian Dol.	Well #4	10-12-60	7.5	220	220	0.06	0.06	14.0	0	228	
Se-P.C. Dol.	Well #1	10-20-59	7.5	1215	1215	0.44	0.44	8.8	0	236	1
olomite	Well #1	10-20-59	7.3	427	427	<0.02	<0.02	21.4	0	302	
-Ma. Ls&Dol.	Well #3	1-17-61	7.4	347	347	0.64	0.64	11.6	0	266	
-Ma. Ls&Dol.	Well #4	1-17-61	7.5	312	312	0.92	0.92	11.6	0	254	
olomite	Well #31	5-20-57	7.5	378	378	<0.05	<0.05	13.6	0	156	
olomite	Well #34	5-20-57	7.5	287	287	0.96	0.96	12.8	0	144	
P.C.-Jor.	Well #42	5-20-57	7.7	315	315	<0.05	<0.05	7.6	0	228	
t.L.	Well #58	3-14-60	7.7	302	302	0.78	0.78	6.8	0	238	
olomite	Well #1	1-17-62	7.4	324	324	1.0	1.0	13.0	0	282	
d & Gravel	Well #1	1-8-62	7.3	356	356	<0.02	<0.02	16.8	0	226	
ns from Des Moines, Iowa											
lomite	Well #1	3-8-60	7.6	400	400	0.32	0.32	10.2	0	292	
olomite	Well #1	3-28-63	7.4	353	353	1.8	1.8	16.8	0	316	
	Well #2	3-28-63	7.4	350	350	1.7	1.7	17.6	0	316	
	Plant Effluent	3-28-63	7.5	352	352	0.12	0.12	16.8	0	309	
y (?)	Well #1	3-29-62	7.4	326	326	0.74	0.74	12.8	0	306	

C

K	Na	Ca	Mg	Mn	NO_3	F	Cl	SO_4	HCO_3	CO_3	Hardness as $CaCO_3$
1.9	8.8	84.8	19.4	< 0.05	< 0.4	0.2	10.5	56.8	283	0	292
1.6	8.2	77.3	17.2	< 0.05	1.3	0.2	10	39.5	273	0	264
1.1	3.5	75.6	17.3	< 0.05	< 0.4	0.2	2	30.5	281	0	260
1.2	6.2	90.7	15.8	< 0.05	16.8	0.2	9	46.7	278	0	292
3.2	264	110	31.8	< 0.05	17.7	1.0	295	324	288	0	406
0.6	3.8	87.2	38.4	< 0.05	23.6	0.2	11	38.5	368	0	376
4.2	16.2	70.4	27.2	< 0.05	2.7	0.9	< 0.5	50.8	325	0	288
3.2	15.0	68.8	24.3	< 0.05	< 0.4	0.8	< 0.5	39.9	325	0	272
2.0	12.5	74.9	19.7	0.05	8.0	0.2	23	105	190	0	268
2.1	9.6	54.9	19.2	0.27	1.8	0.2	15	67.1	170	0	218
3.7	19.1	53.3	26.0	< 0.05	2.7	0.95	5.0	49.6	278	0	240
0.0	20.2	57.1	23.6	< 0.05	< 0.4	1.05	3	45.7	290	0	240
1.5	7.6	57.6	34.0	< 0.05	< 0.4	0.15	0.5	19.8	344	0	284
1.0	11.4	74.4	27.2	< 0.05	10.7	0.15	9.5	61.9	276	0	298
4.2	46.0	58.8	32.3	< 0.05	8.0	0.4	5	78.4	356	0	280
1.9	17.5	76.8	23.3	< 0.05	< 0.4	0.35	< 0.5	8.7	386	0	288
1.8	16.5	76.8	24.3	< 0.05	< 0.4	0.35	< 0.5	7.4	386	0	292
1.8	17.4	76.8	23.8	< 0.05	1.8	0.35	< 0.5	7.9	377	0	290
1.2	18.7	73.6	26.2	< 0.05	< 0.4	0.6	< 0.5	36.8	373	0	292

A

Municipality	Date Installed	Well Depth	Chief Aquifer	Point of Collection	Date Colle
Sumner	1902	1740	St.P.Ss thru St. L. Dol	Well #1	6-1
	1935	45	Pleistocene Sand	Well #2	6-1
	1955	1120	Ft.A.Ls-Ga.Ls-St.P.Ss-P.C. Dolomite	Well #3	6-1
Tripoli	1918	135	Wapsipinicon Limestone	Well #1	4-2
	1953	130	Wapsipinicon Limestone	Well #2	4-2
				Plant Effluent	4-2
Westgate	1906	102	Cedar Valley Limestone	Well	2-8
Wheatland	(1920)	180	Silurian Dolomite (?)	Well #1	8-1
	1960	1328	P.C. Dol-Jor. Ss-St. L. Dol.	Well #2	8-1
				Plant Effluent	9-2
Winthrop	1914	227	Dev. Ls or Sil. Dol.	East Well	8-3
		227	Dev. Ls or Sil. Dol.	West Well	8-3
				Plant Effluent	8-3

B

Appendix No. 1

Quality of Well Water

er	Point of Collection	Date of Collection	pH	Dissolved Solids	TTotal Solids	Soluble Iron	Total Iron	SiO_2	Alkalinity P	Alkalinity T	
St. L. Dol	Well #1	6-14-62	7.8	300	300	0.08	0.08	6.4	0	224	7.
Sand	Well #2	6-14-62	7.0	289	290	0.40	2.0	10.0	0	54.0	3.
s-St.P.Ss- te	Well #3	6-14-62	7.9	316	316	0.12	0.12	6.8	0	242	8.
Limestone	Well #1	4-26-62	7.4	349	349	1.5	1.5	17.2	0	338	1.
Limestone	Well #2	4-26-62	7.4	344	344	1.5	1.5	18.0	0	326	1.
	Plant Effluent	4-26-62	7.4	336	336	0.40	0.40	17.6	0	326	1.
Limestone	Well	2-8-60	7.4	451	451	2.12	2.12	16.2	0	372	2.
lomite (?)	Well #1	8-1-62	7.6	340	340	1.7	1.7	21.6	0	352	1.
. Ss-St.	Well #2	8-1-62	7.7	328	328	1.9	1.9	24.8	0	341	1.
	Plant Effluent	9-2-58	7.8	350	350	0.06	0.06	19.4	0	324	1.
il. Dol.	East Well	8-3-62	7.6	438	438	2.4	2.4	14.8	0	323	3.
il. Dol.	West Well	8-3-62	7.5	443	443	5.2	5.2	16.0	0	314	3.
	Plant Effluent	8-3-62	7.5	441	441	0.08	0.08	14.0	0	308	3.

C

K	Na	Ca	Mg	Mn	NO_3	F	Cl	SO_4	HCO_3	CO_3	Hardness as $CaCO_3$
1	15.1	54.0	23.8	<0.05	<0.4	0.7	1	50.4	273	0	233
4	20.1	44.0	10.0	<0.05	21.9	0.15	29	85.4	65.9	0	151
0	25.8	50.8	23.8	<0.05	0.9	1.1	1	47.5	295	0	225
6	15.7	82.4	24.3	0.10	<0.4	0.4	<0.5	20.8	412	0	306
4	15.1	80.0	24.3	<0.05	<0.4	0.35	<0.5	25.9	398	0	300
5	15.2	78.4	24.8	0.11	<0.4	0.35	<0.5	23.0	398	0	298
8	18.8	101	28.2	<0.05	0.9	0.4	6	45.9	454	0	368
5	13.4	80.0	29.2	<0.05	<0.4	0.2	<0.5	7.6	429	0	320
5	12.0	76.8	32.1	<0.05	<0.4	0.25	<0.5	7.2	416	0	324
7	10.0	72.5	30.9	0.05	<0.4	0.2	3.0	3.5	395	0	308
5	37.2	64.8	36.9	<0.05	<0.4	0.35	0.5	85.6	394	0	314
4	33.2	70.4	36.9	<0.05	<0.4	0.35	<0.5	89.7	383	0	328
5	36.0	66.4	35.0	<0.05	8.8	0.35	<0.5	86.4	376	0	310

Appendix No. 2

Municipal Water Supplies

Municipality	Estimated Pop. Served	Source of Supply	Rated Plant Capacity	Average Output
Anamosa	4,615	Drilled Wells	-*	X**
Calamus	435	Drilled Well	-	X
Central City	1,085	Drilled Wells	-	X
Clarence	860	Drilled Well	X	X
Coggon	670	Drilled Wells	-	X
Dewitt	3,225	Drilled Wells	X	X
Dunkerton	505	Drilled Well	-	X
Elma	705	Drilled Well	X	X
Fairbank	650	Drilled Well	-	X
Fredericksburg	795	Drilled Well	X	X
Grand Mound	565	Drilled Well	-	X
Hazleton	665	Drilled Well	-	X
Ionia	265	Drilled Well	-	X

*Indicates requested information does not apply.

**Indicates no information is available.

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Appendix No. 2 (continued)

Municipal Water Supplies

Municipality	Estimated Pop. Served	Source of Supply	Rated Plant Capacity	Average Output
Independence	5,500	Drilled Wells	X	X
Lowden	640	Drilled Well	X	X
Lost Nation	565	Drilled Well	-	X
New Hampton	3,455	Drilled Wells	-	X
Olin	705	Drilled Well	-	X
Oelwein	8,280	Drilled Wells	X	X
Oxford Junction	725	Dug Well	X	X
Pleasant Hill	(395)	Des Moines	-	-
Prairieburg	225	Drilled Well	-	X
Readlyn	545	Drilled Well	-	X
Riceville	900	Drilled Well	-	X
Sumner	2,170	Drilled Wells	-	X
Tripoli	1,180	Drilled Well	.350	X

Appendix No. 2 (continued)

Municipal Water Supplies

Municipality	Estimated Pop. Served	Source of Supply	Rated Plant Capacity	Average Output
Westgate	215	Drilled Well	-	X
Wheatland	645	Drilled Well	.144	X
Winthrop	650	Drilled Wells	.100	X

Appendix No. 3

Municipal Waste Treatment Facilities
Wapsipinicon River Basin

Community	1960 Population	Estimated Population Served	Discharge to	Type of Treatment	P. E. (BOD) Raw	P. E. (BOD) Discharged
Alta Vista	276	250	Tributary to Middle Branch Wapsipinicon River	Secondary	250E*	50E*
Anamosa	4,616	4,300	Wapsipinicon River	Secondary	7,800E	500
Central City	1,087	950	Wapsipinicon River	Secondary	950E	100E
Clarence	859	950	Mill Creek	Secondary	950	140
Coggon	672	620	Buffalo Creek	Secondary	9,000E	900E
Dewitt	3,224	3,000	Silver Creek to Wapsipinicon River	Secondary	3,600E	500E
Dixon	280	260E*	Creek	Secondary	260E	40E
Elma	706	650	Middle Branch of Wapsipinicon River	Secondary		200E
Fredericksburg	797	700	East Branch of Wapsipinicon River	Secondary		560E
Grand Mound	565	500	Ditch to Wapsipinicon River	Secondary	500E	150E

Appendix No. 3 (Continued)

Community	1960 Population	Estimated Population Served	Discharge to	Type of Treatment	P. E. (BOD) Raw	P. E. (BOD) Discharged
Hazleton	665	630E*	Otter Creek	Secondary	630E*	95E*
Independence	5,498	5,000	Wapsipinicon River	Secondary	6,000E	600E
Lost Nation	567	500	Lost Nation Ditch to Wapsipinicon River	Secondary	700E	70E
Lowden	641	640	Yankee Run Creek to Wapsipinicon River	Secondary		
New Hampton	3,456	2,000	Tributary to East Br. of Wapsipinicon River	Secondary		800E
Oelwein	8,282	8,000	Otter Creek	Secondary	16,000E	1,600E
Olin	703	500	Walnut Creek	None	800E	800E
Oxford Junction	725	400	Wapsipinicon River	None	300E	300E
Riceville	898	700	Wapsipinicon River	Secondary	1,000E	750E
Ryan	347	330E	Local Creek	Secondary	330E	50E
Sumner	2,170	2,000	Tributary to Wapsipinicon River	Secondary	3,500E	300E
Tripoli	1,179	1,000	Wapsipinicon River	Secondary	1,400E	100E
Troy Mills	150	250	Wapsipinicon River	Primary	250E	150E

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Appendix No. 3 (Continued)

Community	1960 Population	Estimated Population Served	Discharge to	Type of Treatment	P. E. (BOD) Raw	P. E. (BOD) Discharged
Wheatland	643	610E*	Yankee Creek	Secondary	610E*	90E*
Winthrop	649	600	Buffalo Creek to Wapsipinicon River	Secondary	800E	80E

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*Estimated

Appendix No. 4

Calculation of Water Quality Needs

Public Law 660 provides that "....storage and water releases shall not be provided as a substitute for adequate treatment or other needs of controlling wastes at their source." Quantities of water required for water quality control are computed on the premises that adequate treatment will be provided. Adequate treatment is defined as 85 percent reduction in BOD.

The oxygen sag formula used in the calculations was the standard Phelps-Streeter Formula. In using this formula, several factors must be evaluated. These factors are dependent upon turbulence of streamflow, velocity, type of waste treatment, temperature and other various parameters. The following figures and values were used in this study:

Item	Summer	Spring & Fall
Deoxygenation Constant, K1	0.1	.063
Reaeration Constant, K2	0.25	.195
D. O. Saturation at Dam (%)	80%	80%
BOD at Dam (mg/1)	3	3
Average Temperature ^{o}C	20	10

It should be noted that the municipalities of Coggon, Anamosa and Lost Nation show industrial waste loads in population equivalent of 8,380, 3,500 and 200, respectively. These industrial loads are derived mainly from creameries and dairies. In order to project

future requirements, it was assumed that these industries would grow at the same rate as the populations.